delineation of soil units. And finally, reproducibility has to include prediction quality assessment.

The expert system consists of four key modules: (1) The segmentation module using a region-growing algorithm leads to scale-specific soil-terrain units based on terrain attributes. (2) Within the transformation module, all soil and auxiliary data are expert-based or geo-statistically transformed into so called 'soil target features' (STF). STF represent soil-forming processes and properties like 'clay illuviation' or 'clay content' and characterize the target soil classes (TSC) - the aim of the prediction. (3) The fuzzy classification module enables the definition of TSC by using logical combinations of two-dimensional membership functions. The membership functions refer to STF-mean values of the segmented soil-terrain units. The classified segments are characterized by class memberships which express core and transition soil zones as well as the prediction quality. (4) The prediction quality can only be assessed by classification validation. Within the validation module accuracy measures can be calculated that are derived from a confusion matrix. The measures show how strong classification results match with random samples of reference information.

S26.D.02
Multiple Additive Regression Trees as a tool for estimating soil properties. Principles and applications

M. Martin[1]*, L. Boulonne*[1]*, G. Bourgeon*[2]*, Y. M. Cabidoche*[3]*, S. Cornu*[1]*, C. Jolivet*[1]*, S. Lehmann*[1]*, D. Lo Seen*[4]*, K. Nair*[5]*, N. Saby*[1]*;*
[1]*INRA US1106 Infosol, Olivet, France,* [2]*: CIRAD - PERSYST, UR Environmental Risks of Recycling, Montpellier, France,* [3]*INRA, Petit Bourg, France,* [4]*CIRAD - ES, UMR TETIS (Cemagref - CIRAD - ENGREF), Montpellier, France,* [5]*National Bureau of Soil Survey and Land Use Planning, Hebbal - Bangalore, India.*

Pedotransfer functions (PTFs) are used to estimate soil properties that are difficult and costly to measure, from others properties that are available. MART, namely Multiple Additive Regression Trees belongs to the boosted regression trees (BRT) family. It has been applied in various scientific fields such as remote sensing, ecology and prediction of species distribution, medicine and chemometrics and only very recently to soil science. The MART method, which includes the use of stochastic gradient boosting, is known for having a set of interesting properties, although as for other techniques such as neural networks, attention must be paid to overfitting behavior. It can work with either qualitative or quantitative predictive variables, can handle missing data, correlated predictive variables and is robust to the presence of outliers within the dataset and to the use of irrelevant predictor variables. It comes with different output for interpreting the results and assessing the validity of the fit.

Here, we present development of PTFs using MART for diverse soil science application as estimation of missing values of bulk density of French metropolitan soils, prediction of soil carbon stocks in Guadeloupe (French Caribbean Island) and development of correspondence function between different methods of heavy metals analysis (aqua regia and total analysis, i.e. inductively coupled plasma mass spectroscopy after dissolution with hydrofluoric and perchloric acids). MART proved to be a versatile and convenient tool for building such functions without much a priori knowledge about the relationships between response variable and predictors. MART was able to grasp the full dataset diversity when fitting PTFs as challenging as PTF for bulk density.

S26.D.03
Topsoil organic carbon content in relation to edaphic and anthropogenic site variables in Rwanda

A. Verdoodt[1]*, E. Van Ranst*[1]*, P. Finke*[1]*, G. Baert*[2]*;*
[1]*Laboratory of Soil Science, Ghent University, Gent, Belgium,*
[2]*Department of Biosciences and Landscape Architecture, Hogeschool Gent, Gent, Belgium.*

In view of ongoing expansion and intensification of agricultural land in Rwanda, protection of soil resources, and especially of organic matter content, is of utmost importance for the majority of its population depending on agriculture. Rwanda has a considerable diversity of soils, ranging from Andosols in the volcanic highlands, over Cambisols, Luvisols, Alisols and Acrisols in the sub-humid, hilly western highlands, to strongly weathered Ferralsols in the semi-arid eastern lowlands. We analysed the nation-wide soil profile database, containing 1463 described and analysed soil profiles distributed across the country and determined to what extent independent site variables such as altitude, soil moisture regime, slope gradient, soil reference group, parent material, internal drainage, granulometry, pH, land use, and population density explain the recorded variation in topsoil (0-30 cm, mineral layer) organic carbon content (O.C). Statistical tools used include regression tree analysis and stepwise general linear modelling. Two linear regressions based on altitude, clay + fine silt or sand content, and population density both explain 48% of the variation in O.C at national level. In the regression tree analysis, including also categorical site variables, the impact of parent material and land use on O.C is highlighted as well. The regression tree - comprising in order of decreasing importance, altitude, parent material, land use, sand content, clay + fine silt content, and population density - explains 53% of the variation in O.C. By adopting a multi-level approach differences in relative importance of the site variables within specific agro-ecological zones can be identified. The analysis provides insight in the O.C pool present in the Rwandan topsoils and highlights challenges faced when characterising the spatial distribution of O.C in environmentally very diverse tropical regions with high population densities.

S26.D.04
Enhanced soil phosphorus mapping with common secondary information

M. Schirrmann[1]*, H. Domsch*[1]*, U. von Wulffen*[2]*, O. Zauer*[3]*, J. Nieter*[3]*;*
[1]*Leibniz-Institute for Agricultural Engineering, Potsdam, Germany,* [2]*State Office of Agriculture, Forestry and Horticulture (LLFG), Bernburg, Germany,* [3]*Dawa-Agrar GmbH & Co.KG, Dahlenwarsleben, Germany.*

A good spatial estimate of soil phosphorus is a key element in a site specific management strategy which helps to reduce economic expenses and its environmental impacts. But a high spatial variation of soil properties in fields, due to numerous influences, makes mapping of soil phosphorus rather problematic. To overcome this problem, an intensive grid soil sampling approach can be applied. However, the increased sample size means high costs and, from the farmer's point of view, is often considered as uneconomical. An alternative is, to assume a relationship of soil phosphorus to secondary spatial data that are more economically sampled.

The purpose of this study was to evaluate the performance of spatial estimates of phosphorus for different prediction methods, with and without incorporating secondary information on multiple scales. As covariates we chose soil conductivity, crop yield data and soil pH. Soil samples were taken on a 36 ha field along a 100 m grid and a 50 m grid with a regular grid design. We combined both grids so that three grids could be yielded. Correlation and cluster analysis were performed to reveal relationships between nutrients and covariates. Soil phosphorus estimation maps were created from each grid using inverse